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SEASONAL ABUNDANCE, SIZE DISTRIBUTION, AND BLOOD BIOCHEMICAL VALUES OF LOGGERHEADS (*CARETTA CARETTA*) IN PORT CANAVERAL SHIP CHANNEL, FLORIDA

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U.S. Department of Commerce
National Oceanographic and Atmospheric Administration
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Southeast Fisheries Science Center
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U.S. DEPARTMENT OF COMMERCE
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NOTICE

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EXECUTIVE SUMMARY

1. Monthly trawler surveys were conducted in the Port Canaveral Ship Channel from March 1992 through February 1993. A total of 174 turtles were captured: 171 loggerheads (*Caretta caretta*); 2 green turtles (*Chelonia mydas*); and 1 Kemp's ridley (*Lepidochelys kempi*).

2. Equal survey effort (in trawl time and distance) among months and among survey stations allowed for direct statistical comparison of turtle captures among months and among stations. The number of loggerheads captured varied significantly by month and by station.

3. The size frequency of all loggerheads captured has a strong bimodal distribution. Juveniles occurred in Port Canaveral Ship Channel in all months. More adults were present in spring and summer months than in fall and winter months.

4. No individual turtle was captured more than once during any monthly survey. However, 6 loggerheads tagged during the monthly surveys were recaptured during later monthly surveys. Also, 17 loggerheads tagged by other tagging projects were recaptured during the survey year.

5. Five turtles tagged during this project were later reported away from Port Canaveral Ship Channel: 1 green turtle and 2 loggerheads were observed nesting; 1 loggerhead stranded dead 13 months later in Chesapeake Bay; and 1 loggerhead stranded dead north of Port Canaveral Ship Channel.

6. Catch per unit effort (CPUE) was calculated to facilitate comparisons with other projects. CPUE for juvenile loggerheads has declined since 1980 (Henwood 1987) for the Port Canaveral Ship Channel.

7. Baseline blood values were determined for 26 analytes. All analytes except chloride, alkaline phosphatase, gamma-glutamyl transferase, and total iron showed a significant month effect. In general, all values increased during warmer temperatures except BUN which declined during warmer months. All analytes except inorganic phosphorus, gamma-glutamyl transferase, total iron, and total cholesterol had a significant relationship to body size.

8. The following physical parameters were recorded during each monthly survey: air and water temperatures, barometric pressure, wave height, tide cycle, and Channel depth. There was a significant correlation between water temperature and the numbers of adult loggerheads captured each month. Numbers of juvenile loggerheads captured each month were not correlated with water temperature.

INTRODUCTION

In 1991, the Waterways Experiment Station (U.S. Army Corps of Engineers) developed an integrated program to evaluate relative abundance of sea turtles in a number of channels in the southeastern U.S. that are maintained by the U.S. Army Corps of Engineers. It was recognized that we needed to learn more about the sea turtle populations in these channels so that appropriate management plans could be developed. This Technical Memorandum summarizes the results from monthly surveys of the sea turtle populations in the Port Canaveral Ship Channel, Florida (28°23'N, 80°33'W), from March 1992 through February 1993. The objectives of this aspect of the program were to evaluate species composition, size class frequencies, relative abundance, and seasonal and spatial distributions. In addition, baseline blood chemistry parameters were determined for loggerhead sea turtles (*Caretta caretta*).

The Port Canaveral Ship Channel has been recognized as an important habitat for sea turtles (Carr et al. 1980; Ogren and McVea 1982; Henwood 1987; Henwood and Ogren 1987; Witzell 1987). The need to maintain the Channel for navigation for both commercial and military vessels has resulted in the take of turtles from dredging operations (Dickerson and Nelson 1990).

Since the late 1970's sea turtle populations in the Channel have been periodically surveyed using commercial trawling vessels. Henwood (1987) summarized the data from surveys conducted from 1978 to 1984 with respect to species, size frequency distribution, and seasonality. From March 1988 until March 1991, periodic surveys of sea turtle populations in the Channel have been conducted by researchers at the Archie Carr Center for Sea Turtle Research, University of Florida (Bolten and Bjorndal 1990 and unpubl. reports).

This project accomplished the immediate goal of the U.S. Army Corps of Engineers to obtain information to enable development of management plans to reduce negative effects of dredging on sea turtles. In addition, this study provided the opportunity to collect data on an in-water sea turtle population throughout an annual cycle. Several federally sponsored task forces, organized to evaluate issues in conservation and management of sea turtles, have stressed the need for more studies on in-water sea turtle populations (National Research Council 1990; Tucker and Associates 1990; National Marine Fisheries Service and U.S. Fish and Wildlife Service 1991).

METHODS

Trawler and Net Design

To conduct the monthly surveys, we chartered the commercial fishing vessel *Mickey Anne*, which is owned and captained by Eddie Chadwick. The trawler was double-rigged with two 60-foot trawling nets (manufactured by Billy Burbank, Jr., Fernandina, FL) made of large mesh webbing (8-inch stretch) to lessen by-catch. See Appendix 1 for net specifications.

Sampling Protocol

In order to facilitate comparison with surveys being conducted in other channels, sampling protocol was standardized. The Port Canaveral Ship Channel was divided into four sampling stations (Table 1). Each of these stations combined two of the original NMFS survey stations developed for Port Canaveral Ship Channel (Butler et al. 1987). Therefore, comparisons can be made with earlier studies.

Monthly surveys were conducted from March 1992 through February 1993. Each survey period consisted of three days with each of the four survey stations being sampled twice each day for a total of 24 tows per monthly survey. Each tow was approximately 1.08 nautical miles. Positions at the beginning and end of each tow were determined using LORAN navigational equipment. To the extent possible, trawling speed was maintained at a constant rate. Tow speed was taken at the approximate mid point of each tow. Data for each tow and monthly survey summaries were entered on standard data forms provided by the U.S. Army Corps of Engineers (Appendix 2).

Turtle Handling and Measurements

All captured turtles were identified to species, measured, tagged, and released back into the Channel. Prior to release, blood samples were taken (see below). Turtles were double-tagged with #681 Inconel tags (National Band and Tag Company, Newport, Kentucky). Tags were engraved with a unique identification number and a reward message in English and Spanish to encourage tag returns. The following measurements were taken: maximum straight carapace length, standard straight carapace length (from nuchal notch to posterior marginal tip), minimum straight carapace length (from nuchal notch to posterior marginal notch), curved carapace length (from nuchal notch to posterior marginal notch), maximum straight carapace width, straight plastron length, maximum head width, tail lengths (from posterior plastron to cloaca and from posterior plastron to tip of tail), and weight. In this Technical Memorandum, straight carapace length (SCL) refers to standard straight carapace length unless noted otherwise. Data were entered into field books and transcribed onto standard data forms provided by the U.S. Army Corps of Engineers (Appendix 2).

Blood Collection and Analyses

Blood samples were collected and handled as described in Bolten and Bjorndal (1992) and Bolten et al. (1992). Blood samples were collected from the dorsal cervical sinus (Owens and Ruiz 1980) using 20-gauge 1.5" needles and lithium-heparinized vacutainer tubes. Whole blood in the vacutainer tubes was centrifuged for 5 minutes. The plasma was pipetted into cryogenic vials and stored in liquid nitrogen. There was no evidence of hemolysis. No more than 15 minutes elapsed from the time that the blood was drawn until storage of the plasma in liquid nitrogen.

Plasma samples were transported in liquid nitrogen to the Archie Carr Center for Sea Turtle Research, University of Florida, and stored at -70°C until analyzed. Plasma samples were evaluated by a commercial laboratory (SmithKline Beecham Clinical Laboratories, Tampa, Florida) using an Olympus AU5061 autoanalyzer.

Except for mature males, sex of sea turtles cannot be determined from external characteristics. Circulating testosterone titers have been used successfully to determine sex of immature sea turtles (Owens et al. 1978; Wibbels 1988). Plasma testosterone concentrations were measured using a radioimmunoassay with an antisera developed and validated for loggerheads by the Reproductive Analysis Core, Biotechnologies for the Ecological, Evolutionary and Conservation Sciences, University of Florida.

Water Quality and Physical Measurements

Water temperature measurements using a YSI meter were taken at the surface, mid-depth, and bottom of the Channel during each sampling period. The YSI temperature probe was calibrated prior to each sampling period. Weather conditions (air temperature, wind velocity and direction, wave height, and precipitation) were recorded for each survey period. These weather data were obtained from the local weather service. Time of high and low tides were obtained from the local newspaper and recorded for each tow.

Data Analyses

Data were statistically analyzed using SAS Release 6.07 and Minitab Release 7.2, VAX/VMS Version. Parametric tests (ANOVA; SAS Institute 1982) and non-parametric tests (one and k-sample chi-square, Spearman rank correlations; Siegel 1956; Ryan et al. 1985) were used as appropriate (Zar 1984). Unless otherwise stated, alpha = 0.05 for all analyses.

To assess differences in monthly or seasonal abundance between adults and juveniles, we classified turtles less than 80.0 cm standard straight carapace length as juveniles. This size was selected based on the bimodal distribution of turtle sizes (see Results section) and also is similar to the minimal size reported for 119 nesting Florida loggerheads (80.9 cm; Witherington 1986).

Permits

All work was conducted under National Marine Fisheries Service (#664) and Florida Department of Natural Resources (TP#016) permits to the Archie Carr Center for Sea Turtle Research, University of Florida. All animal care was in full compliance with the University of Florida Institutional Animal Care and Use Committee (permit #8279).

RESULTS

Trawl Effort

Total trawl distance (nautical miles) in each station for the survey each month is given in Figure 1. There was no significant difference in total trawl distance among months or among stations (k-sample chi-square, df = 33, chi-square = 19.303). The mean and standard deviation for total trawl distance (nautical miles) for each station each month is 6.47 ± 0.20 (n = 48).

Total trawl time (minutes) in each station for the survey each month is given in Figure 2. There was no significant difference in total trawl time among months or among stations (k-sample chi-square, df = 33, chi-square = 5.494). The mean and standard deviation for total trawl time (minutes) for each station each month is 153 ± 10 (n = 48).

The lack of effect of month or station on trawl distance and trawl time indicates that there was no significant difference in the trawl effort among months or among stations. This equal effort allows direct statistical comparison of turtle captures among months and among stations.

Over the twelve month period, 82 sea turtles were captured in the port net, and 92 were captured in the starboard net. There was not a significant difference in number of turtles captured in the port net and the starboard net (1-sample chi-square test, df = 1, chi-square = 0.57). Numbers of turtles captured in each net during each survey month are presented in Figure 3.

Tow speed was recorded at the half-way point for each tow. The mean range of tow speeds was from 2.3 to 2.7 knots.

Turtles Captured

A total of 174 turtles were captured during the trawl surveys. These included 171 loggerheads (*Caretta caretta*), 2 green turtles (*Chelonia mydas*), and 1 Kemp's ridley (*Lepidochelys kempi*). The loggerheads ranged in standard straight carapace length (SCL) from 40.2 to 109.8 cm and were captured in every month of the year. The green turtles had SCL of 52.0 and 98.5 cm, and were captured in April 1992 in Station A and in June 1992 in Station B, respectively. The Kemp's ridley had a SCL of 30.8 cm and was captured in January 1993 in Station B. Because of the small numbers of green turtles and Kemp's ridleys, the analyses of turtle captures that follow are based only on loggerheads.

The numbers of loggerheads captured each month in each station are presented in Figure 4. The number of loggerheads varied significantly by month (1-sample chi-square, df = 11, chi-square = 74.96, $P < 0.001$). The large number of months in which no turtles were captured in Station A and/or D, precluded a statistical analysis of number of turtles captured by station in each month. However, inspection of Figure 4 reveals clear differences in the numbers of loggerheads captured in each station by month. If the numbers of loggerheads captured in each station are summed for the survey year, the totals are 23 in Station A, 62 in Station B, 85 in Station C, and 1 in Station D (Figure 5). There is a significant difference among the total numbers of loggerheads captured in each station (1-sample chi-square test, df = 3, chi-square = 100.32, $P < 0.001$).

The size (standard straight carapace length) frequency of all loggerheads captured in Port Canaveral Ship Channel during the survey year has a strong bimodal distribution (Figure 6). The size frequency distributions of loggerheads captured in each month are given in Figures 7-18. Considerable variation in size frequencies occurred among months.

The distribution of the two size classes--juveniles and adults--over each month of the survey year is shown in Figure 19. Juveniles occur in Port Canaveral Ship Channel in every month of the year. There is a significant difference in the numbers of juvenile loggerheads captured among months if all months are considered (1-sample chi-square test, df = 11, chi-square = 43.56, $P < 0.001$). However, if January is omitted from the analysis, there is no significant difference in the numbers of juvenile loggerheads captured among months (1-sample chi-square test, df = 10, chi-square = 13.2).

Because of the number of months in which adults were not captured, similar analysis of the distribution of adults among months is not possible (too many cells with values less than 5 for chi-square analysis). For the same reason, it is not possible to compare the distributions of juvenile loggerheads and adult loggerheads across all months.

However, from the distributions in Figure 19 it appears that the frequency of adult loggerheads is not constant across all months, with more adults in spring and summer months than in fall and winter months. It also appears that the distributions of juvenile and adult turtles are different. To test these two hypotheses, numbers of juvenile and adult loggerheads were summed for spring (March, April, May), summer (June, July, August), fall (September, October, November), and winter (December, January, February) months. The number of adult loggerheads did vary significantly among the four seasons (1-sample chi-square test, df = 3, chi-square = 66.26, $P < 0.001$). Also, the distributions of juvenile and adults over the four seasons were significantly different (k-sample chi-square test, df = 3, chi-square = 56.85, $P < 0.001$).

Concentration of plasma testosterone was determined for all loggerheads. However, identification of the sex of the turtles based on testosterone titers was not possible. Distribution of testosterone concentrations was not bimodal; that is, there was no clear division between males and females.

No individual turtle was captured more than once within any monthly survey. However, six loggerheads tagged during the monthly surveys were recaptured during later monthly surveys. Also, 17 loggerheads tagged by other tagging projects were recaptured during the survey year.

Five turtles tagged during this project were later reported at locations other than Port Canaveral Ship Channel. One adult loggerhead, which was captured in the trawl survey in June and was noted as lethargic with a sunken plastron, stranded dead three days later 3.6 km north of the Port Canaveral north jetty. Another adult loggerhead, which had been captured in the May 1992 trawl survey, stranded dead in Chesapeake Bay 13 months later in June 1993 (D.

Keinath, pers. comm.). Three turtles were reported nesting a short time after they were captured in Port Canaveral Ship Channel. A green turtle captured on 19 June 1992 nested on Melbourne Beach, Florida, on 7 July 1992 (S. Johnson, pers. comm.). A loggerhead captured on 19 June 1992 nested on Hutchinson Island, Florida, on 9 July 1992. Another loggerhead captured on 10 July 1992 nested on Cocoa Beach, Florida, on 30 July 1992. Apparently, the capture in the trawl survey did not significantly disrupt reproductive behavior for these three females.

Catch Per Unit Effort

Catch per unit effort (CPUE) was calculated as number of turtles captured per tow hour per 36.6 m wide net and number of turtles captured per tow nautical mile per 36.6 m wide net (Table 2). CPUE was calculated in this manner to facilitate comparison of CPUE's measured in other channels as part of the overall program to assess sea turtle relative abundance in the southeastern U.S. being conducted by the Waterways Experiment Station (U.S. Army Corps of Engineers). The CPUE values were calculated for all four Stations, and for just Stations A, B and C (Table 2). Station D data were omitted from calculations of the latter CPUE because only one turtle was caught in that station during the year, and Station D is west of the area of the Channel that is being maintained by dredging by the U.S. Army Corps of Engineers.

Blood Chemistry

Mean values and standard deviations for 26 analytes in plasma of loggerheads captured in Port Canaveral Ship Channel are presented in Table 3. Values are presented for the entire year and for each month. All analytes except chloride, alkaline phosphatase, gamma-glutamyl transferase, and total iron showed a significant month effect (one-way ANOVA, Table 4). All analytes except inorganic phosphorus, gamma-glutamyl transferase, total iron, and total cholesterol had a significant relationship with body size (Spearman rank correlations, Table 4).

Physical Parameters

Air and water temperatures are shown in Figure 20. There was no variation in temperature from the water surface to the bottom of the Channel, apparently because the water is well-mixed. There was no significant correlation between water temperature and the total number of loggerheads captured each month (Figure 21; Spearman rank correlation, $n = 12$, $r_s = 0.260$) or between water temperature and the number of juvenile loggerheads captured each month (Figure 22; Spearman rank correlation, $n = 12$, $r_s = -0.444$). There was a significant correlation between water temperature and the number of adult loggerheads captured each month (Figure 23; Spearman rank correlation, $n = 12$, $r_s = 0.531$, $P < 0.05$, one-tailed test).

Surveys were only conducted during relatively calm weather. Mean barometric pressure during the monthly surveys varied from 29.9 to 30.2 inches. Mean range of wave height during monthly surveys was from 1-2 feet to 5-7 feet. There was no apparent effect of sea state on turtle captures. Tidal flow and currents are weak in the Channel, so their effect on turtle captures was not evaluated.

Channel depth was recorded at the beginning and end of each tow. Figure 24 shows the mean depth (feet) for each station over the twelve-month project. Station D was consistently deeper than the other stations throughout the survey year.

Dredging operations in Port Canaveral Ship Channel were present during surveys conducted in June, July and August. Dredging activity was limited to Station A. All dredging was conducted with a bucket dredge.

DISCUSSION

Species Composition

The sea turtle populations in Port Canaveral Ship Channel are dominated by loggerheads. The loggerhead population is discussed in greater detail in the following sections.

Although only one Kemp's ridley was captured during the survey year, other surveys have indicated that the Channel is important habitat for immature Kemp's ridleys (Henwood and Ogren 1987; Bolten and Bjorndal 1990 and unpubl. reports). Relative abundance of Kemp's ridleys in the Channel appears to be the result of water temperatures and the migratory patterns of Kemp's ridleys north and south along the east coast of the U.S. (Henwood and Ogren 1987).

Henwood and Ogren (1987) suggested that the small numbers of green turtles that inhabited the Port Canaveral Ship Channel represented an itinerant population, including a number of green turtles that had recently left the pelagic habitat and were recruiting to benthic foraging areas. Our earlier surveys (Bolten and Bjorndal, unpubl. reports) indicated that small green turtles in the area congregate close inshore around the jetties and in the submarine basin. A study of the green turtles in this area is now underway (L.M. Ehrhart, University of Central Florida).

Our capture of an adult female green turtle that nested a short time later on Melbourne Beach, Florida, increases the value of the Channel habitat for green turtles. Green turtles apparently use the Channel as an inter-nesting habitat. The capture of adult breeding green turtles may be a rare event in Port Canaveral Ship Channel because the endangered Florida green turtle nesting population is very small (Witherington and Ehrhart 1989; National Research Council 1990).

Size Frequency, Seasonal Distribution and Relative Abundance

The size frequency of loggerheads captured in Port Canaveral Ship Channel has a strong bimodal distribution (Figure 6). The distribution suggests that the two size classes may use the Channel habitat for different purposes, and that they may move in and out of the Channel at different times. Following Henwood (1987), we designated the two size classes as juveniles and adults, but we dived the size classes at 80.0 cm SCL. For 119 nesting loggerheads on Melbourne Beach, Florida, the smallest SCL measured was 80.9 cm (Witherington 1986). Although a few immature loggerheads may have been included in the adult class and a few sexually mature loggerheads may have been included in the juvenile class, it is unlikely that a few misclassified turtles would have an effect on the results reported here because the analyses are limited to questions at the population level, rather than at the individual level.

From the monthly distribution of the two size classes (Figure 19), it is clear that the two size classes have different seasonal distributions. When numbers of loggerheads in the two size classes were combined into four three-month seasons to allow statistical comparison, a significant difference between the distribution of the two size classes was found. Juveniles occupy the channel year round in relatively constant numbers and apparently use the channel as an area in which to rest and/or feed. Adults essentially move into the Channel during the breeding season and use the Channel as an area in which to mate (copulating pairs have been observed in earlier surveys in the Channel) and females use the area as an inter-nesting habitat. This last use was confirmed by the reports of three turtles (two loggerheads and one green turtle) nesting on Florida beaches within a few weeks of capture in Port Canaveral Ship Channel. The significant correlation of adult abundance with water temperature (Figure 23) is a reflection of the fact that loggerheads breed during the warm months of the year.

The sharp increase in number of juvenile loggerheads in the Channel in January (Figure 19) probably represents a group of juvenile turtles migrating south away from cooler northern temperatures. Juvenile loggerheads apparently have a similar migratory pattern to that reported for Kemp's ridleys (Henwood 1987; Henwood and Ogren 1987). As waters along the eastern U.S. coast begin to warm in spring and summer months, they move north, and then move south as temperatures cool in fall and winter months. Apparently the appearance of these migrating loggerheads is determined more by water temperature than by absolute time of year. Thus, these peaks can appear in almost any month from late fall to early spring.

The seasonal distribution of juveniles and adults described above is the same as that reported by Henwood (1987) for loggerheads in the Port Canaveral Ship Channel based on surveys conducted between 1978 and 1984. To compare the CPUE data in Table 2 with those presented by Henwood (1987) for 1980, juvenile loggerheads in this study were redefined as all turtles with maximum carapace length $\leq$ 83 cm as in Henwood (1987). Also, the CPUE data were adusted to account for the difference in the sizes of the trawl nets used in this study (36.6 m wide) and in Henwood's study (30.5 m wide). For juvenile loggerheads, our maximum CPUE (in January in Stations A, B and C) is 2.14 juvenile loggerheads caught per hour per 30.5 m net. Our minimum CPUE (in September in Stations A, B, C and D) is 0.082 juvenile loggerheads caught per hour per 30.5 m net. The comparable range of CPUE from Henwood (1987) is 2.0 to 12.05 juvenile loggerheads caught per hour per 30.5 m net. Based on these CPUE values, the relative abundance of juvenile loggerheads in Port Canaveral Ship Channel has declined between 1980 (Henwood 1987) and this study (1992-1993).

Spatial Distribution

There was significant differential use of the four stations in the Channel by loggerheads (Figure 5). Turtles were present in higher numbers in Stations B and C than in Station A, and only one turtle was captured in Station D. Because we do not know what factors attract loggerheads to Port Canaveral Ship Channel, it is difficult to interpret this differential distribution. The distribution may be correlated with bottom type. Stations B, C and D have softer substrates than Station A, and Station D does not have the steep-sided channel of the other Stations, which may provide shelter to the turtles or act to concentrate organisms on which the turtles feed.

Blood Chemistry

Blood samples were collected from 168 loggerheads, and plasma samples were evaluated for 26 analytes. It is important to establish baseline values for blood chemistries to monitor physiological status of loggerhead populations.

In this study, 22 of the 26 analytes had a significant seasonal effect; only chloride, alkaline phosphatase, gamma-glutamyl transferase, and total iron did not (Table 4). For those analytes with a significant seasonal effect, values increased in warmer months, except for urea nitrogen (BUN), which decreased in warmer months (Table 3). Lutz and Dunbar-Cooper (1987) also evaluated blood chemistry of loggerheads in Port Canaveral Ship Channel. Seven chemical parameters--glucose, sodium, potassium, chloride, magnesium, calcium, and urea--were evaluated in both studies. Of the seven parameters, we found that only chloride did not vary significantly by month. Although Lutz and Dunbar-Cooper did not test statistically for a seasonal effect, they reported that concentrations of sodium, potassium, and chloride showed seasonal trends.

Concentrations of 22 of the 26 analytes are significantly related to body size in the loggerheads in this study. In a study of plasma samples from 100 juvenile green turtles from the southern Bahamas, only 13 of the 23 analytes determined in common between the two studies showed a significant correlation with body size (Bolten and Bjorndal 1992). The greater effect of body size reported here for loggerheads may result from the fact that the loggerhead samples included many reproductively active adults, whereas the green turtle sample included only immature turtles.

Additional analyses have been conducted on these blood samples. Crain (1994) analyzed effect of season, body size and sex on concentrations of insulin-like growth factor I, and Gregory (1994) evaluated capture stress on plasma corticosterone concentrations.

RECOMMENDATIONS

1. The sea turtle populations in Port Canaveral Ship Channel should be surveyed with trawlers at regular intervals to monitor changes in the population. It is important to continue to monitor the Port Canaveral Ship Channel sea turtle population, not only because of its large size, but also because it is one of only a few in-water populations that has a long-term monitoring history. Because it has been demonstrated that population levels in Port Canaveral Ship Channel can change, populations must be surveyed to update their status and potential for negative impacts from dredging.

2. To understand and predict patterns of relative abundance and distribution of turtles within the Channel, the basic biology (particularly, behavior, nutrition, and physiology) of the turtles should be studied to determine why the turtles are in the Channel and how they use the habitat.

3. Although water temperatures affect turtle abundance in the Channel, dredging windows should not be based on temperature data alone. Prior to dredging, pre-dredge surveys should be conducted to establish what species of sea turtle are present and at what levels of abundance. Because the critically endangered Kemp's ridley and Florida green turtle inhabit the Channel on a less predictable basis than do loggerheads, the pre-dredge surveys would be particularly important to determine the presence and abundance of these two species.

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Table 1. Sampling stations for Port Canaveral Ship Channel.

LORAN West Point	LORAN East Point	Station	NMFS Station
43970.7 62037.1	43957.2 62028.5	A*	7 & 8
43957.2 62028.5	43939.5 62022.1	B	9 & 10
43939.5 62022.1	43921.0 62015.0	C	11 & 12
43921.0 62015.0	43901.7 62007.7	D	13 & 14

*Station A has a dog-leg at 43965.0/62031.6

Table 2. Catch per unit effort (CPUE) based on tow time (number of turtles per hour per 36.6 m wide net) and tow distance (number of turtles per nautical mile per 36.6 m wide net) for all Stations and for Stations A, B and C.

ALL FOUR STATIONS:

Month	Number of Turtles	Time (min)	Distance (nm)	CPUE per hr	CPUE per nm
Mar	8	572	26.40	0.84	0.303
Apr	30	602	25.92	3.00	1.157
May	22	583	25.99	2.28	0.846
Jun	33	611	25.90	3.24	1.274
Jul	18	581	25.98	1.86	0.693
Aug	9	569	25.40	0.96	0.354
Sep	3	610	25.12	0.30	0.119
Oct	12	621	25.57	1.14	0.469
Nov	9	654	25.97	0.84	0.347
Dec	2	654	26.13	0.18	0.077
Jan	21	634	25.80	1.98	0.814
Feb	7	642	26.37	0.66	0.265

STATIONS A, B AND C:

Month	Number of Turtles	Time (min)	Distance (nm)	CPUE per hr	CPUE per nm
Mar	8	427	19.92	1.14	0.402
Apr	30	446	19.44	4.02	1.543
May	22	435	19.48	3.06	1.129
Jun	33	456	19.40	4.32	1.701
Jul	17	437	19.48	2.34	0.873
Aug	9	422	18.92	1.26	0.476
Sep	3	447	18.56	0.42	0.162
Oct	12	459	19.01	1.56	0.631
Nov	9	480	19.44	1.14	0.463
Dec	2	487	19.64	0.24	0.102
Jan	21	468	19.26	2.70	1.090
Feb	7	462	19.44	0.90	0.360

Table 3. Mean (standard deviation) for 26 analytes in plasma of loggerheads captured in Port Canaveral Ship Channel, Florida, from March 1992 to February 1993.

Month	N*	GLU	NA	K	CL	MG	CA	P	TP
Total	168	97 (21)	158 (5)	4.3 (0.7)	118 (4)	6.3 (1.4)	7.1 (2.0)	8.4 (1.9)	4.1 (1.0)
Mar	8	95 (7)	158 (3)	3.6 (0.8)	118 (2)	6.4 (0.9)	6.4 (1.1)	6.7 (1.1)	3.8 (1.1)
Apr	29	97 (20)	156 (4)	3.9 (0.3)	117 (4)	6.7 (1.0)	6.1 (1.2)	7.3 (1.4)	4.6 (1.2)
May	18	97 (14)	155 (4)	3.8 (0.4)	118 (4)	7.0 (1.1)	6.9 (1.6)	8.8 (1.6)	4.6 (1.1)
Jun	31	111 (26)	158 (6)	4.0 (0.7)	118 (3)	7.5 (1.1)	8.2 (2.8)	9.3 (2.6)	4.4 (0.8)
Jul	19	104 (13)	160 (5)	4.5 (0.8)	120 (3)	7.3 (0.9)	8.1 (2.0)	8.6 (2.5)	3.9 (0.8)
Aug	9	104 (18)	166 (7)	5.0 (0.8)	120 (3)	6.6 (1.1)	8.9 (3.5)	9.6 (2.0)	4.0 (0.8)
Sep	4	118 (29)	159 (2)	5.3 (0.9)	117 (6)	4.3 (0.5)	7.2 (0.5)	8.7 (1.2)	4.5 (1.8)
Oct	12	90 (18)	157 (2)	4.4 (0.4)	118 (2)	4.3 (0.7)	6.8 (0.9)	8.3 (0.7)	3.9 (1.1)
Nov	9	78 (15)	159 (3)	4.5 (0.5)	117 (3)	4.1 (0.5)	6.4 (0.6)	7.8 (1.2)	3.8 (0.7)
Dec	2	89 (-)	162 (-)	5.2 (-)	118 (-)	5.2 (-)	6.3 (-)	8.15 (-)	3.2 (-)
Jan	20	85 (12)	160 (3)	4.6 (0.4)	117 (4)	5.1 (0.5)	6.6 (0.6)	8.3 (1.5)	3.6 (0.5)
Feb	7	73 (8)	159 (3)	4.8 (0.4)	115 (3)	5.3 (0.3)	6.1 (0.9)	8.4 (1.1)	3.6 (0.8)

* N is sample size; GLU is glucose (mg/dl); NA is sodium (meq/liter); K is potassium (meq/liter); CL is chloride (meq/liter); MG is magnesium (meq/liter); CA is calcium (mg/dl); P is inorganic phosphorus (mg/dl); TP is total protein (g/dl)

Table 3 continued

Month	N*	ALB	GLB	A/G	BIL	ALK	LDH	GGT	AST	ALT
Total	168	0.9 (0.3)	3.2 (0.9)	0.3 (0.1)	0.10 (.11)	15 (9)	110 (72)	3 (3)	204 (90)	2 (2)
Mar	8	0.9 (0.2)	2.9 (1.2)	0.4 (0.2)	0.04 (.05)	11 (6)	144 (110)	3 (2)	142 (43)	2 (1)
Apr	29	0.8 (0.2)	3.7 (1.1)	0.3 (0.1)	0.08 (.05)	12 (6)	143 (87)	3 (2)	200 (44)	2 (2)
May	18	1.0 (0.2)	3.7 (1.0)	0.3 (0.1)	0.12 (.09)	12 (7)	142 (74)	2 (2)	213 (66)	2 (2)
Jun	31	1.1 (0.3)	3.3 (0.7)	0.3 (0.1)	0.18 (.19)	18 (14)	116 (74)	4 (5)	247 (147)	3 (2)
Jul	19	0.9 (0.2)	2.9 (0.7)	0.3 (0.1)	0.10 (.05)	11 (8)	99 (41)	3 (2)	196 (45)	1 (1)
Aug	9	0.9 (0.1)	3.1 (0.8)	0.3 (0.1)	0.10 (0)	13 (2)	83 (27)	1 (1)	193 (65)	2 (4)
Sep	4	0.7 (0.2)	3.8 (1.7)	0.2 (0.1)	0.15 (.19)	21 (12)	100 (41)	2 (2)	191 (56)	1 (2)
Oct	12	0.8 (0.2)	3.2 (1.1)	0.3 (0.1)	0.08 (.10)	18 (5)	111 (90)	2 (3)	232 (114)	1 (2)
Nov	9	0.7 (0.2)	3.1 (0.6)	0.2 (0.1)	0.09 (.09)	17 (7)	86 (39)	3 (4)	228 (83)	1 (3)
Dec	2	0.9 (-)	2.3 (-)	0.4 (-)	0.15 (-)	15 (-)	52 (-)	4 (-)	138 (-)	0 (-)
Jan	20	0.8 (0.3)	2.8 (0.6)	0.3 (0.1)	0.08 (.10)	14 (8)	58 (23)	3 (3)	169 (80)	0 (1)
Feb	7	0.8 (0.3)	2.9 (0.8)	0.3 (0.1)	0 (0)	17 (11)	84 (62)	3 (4)	149 (36)	0 (0)

* N is sample size; ALB is albumin (g/dl); GLB is globulin (g/dl); A/G is albumin/globulin ratio; BIL is total bilirubin (mg/dl); ALK is alkaline phosphatase (U/liter); LDH is lactate dehydrogenase (U/liter); GGT is gamma-glutamyl transferase (U/liter); AST is aspartate aminotransferase or SGOT (U/liter); ALT is alanine aminotransferase or SGPT (U/liter)

Table 3 continued

Month	N*	BUN	CRE	B/C	URIC	FE	TIBC	IS	CHOL	TRIG
Total	168	39 (28)	0.3 (0.1)	149 (136)	0.9 (0.3)	41 (33)	164 (78)	29 (17)	170 (89)	212 (334)
Mar	8	61 (30)	0.3 (0.1)	232 (152)	0.7 (0.4)	32 (13)	204 (100)	18 (9)	168 (91)	47 (30)
Apr	29	52 (26)	0.4 (0.1)	168 (176)	1.0 (0.4)	37 (14)	152 (54)	26 (11)	121 (60)	53 (34)
May	18	32 (27)	0.5 (0.1)	91 (127)	1.2 (0.4)	49 (28)	174 (57)	31 (23)	183 (76)	217 (367)
Jun	31	20 (27)	0.4 (0.1)	65 (102)	1.0 (0.3)	43 (17)	145 (63)	34 (16)	229 (99)	647 (432)
Jul	19	23 (35)	0.3 (0.1)	87 (149)	0.7 (0.2)	56 (82)	163 (92)	32 (19)	212 (68)	373 (275)
Aug	9	37 (20)	0.3 (0.1)	134 (58)	0.7 (0.2)	31 (12)	150 (48)	22 (11)	179 (89)	113 (111)
Sep	4	62 (22)	0.3 (0.1)	231 (88)	0.9 (0.2)	26 (9)	123 (45)	24 (15)	91 (39)	32 (14)
Oct	12	45 (14)	0.3 (0.1)	168 (100)	0.9 (0.2)	45 (17)	138 (38)	34 (12)	131 (89)	43 (43)
Nov	9	55 (12)	0.2 (0.1)	244 (71)	0.7 (0.1)	41 (9)	129 (81)	39 (16)	117 (64)	23 (21)
Dec	2	50 (-)	0.3 (-)	204 (-)	0.9 (-)	54 (-)	352 (-)	5 (-)	222 (-)	18 (-)
Jan	20	49 (14)	0.2 (0.1)	240 (79)	0.7 (0.1)	31 (17)	206 (93)	20 (18)	164 (83)	23 (15)
Feb	7	40 (14)	0.2 (0)	201 (68)	0.7 (0.1)	29 (24)	224 (158)	30 (33)	135 (68)	35 (22)

* N is sample size; BUN is urea nitrogen (mg/dl); CRE is creatinine (mg/dl); B/C is BUN/creatinine ratio; URIC is uric acid (mg/dl); FE is total iron (mcg/dl); TIBC is total iron binding capacity (mcg/dl); IS is percent iron saturation (%); CHOL is total cholesterol (mg/dl); TRIG is triglycerides (mg/dl)

Table 4. Relationships of month and body size (standard straight carapace length) with blood analytes for loggerheads in Port Canaveral Ship Channel, Florida, from March 1992 through February 1993. Differences among months were analyzed with one-way ANOVA (N = 168); relation with body size was analyzed with Spearman rank correlation (N = 165). Abbreviations of analytes are as in Table 3.

Analyte	Month F	Month P	Straight Carapace Length r_s	Straight Carapace Length P
GLU	5.64	< 0.001	0.282	0.0002
NA	4.80	< 0.001	-0.262	0.0007
K	8.66	< 0.001	-0.330	0.0001
CL	1.56	0.116	-0.176	0.0234
MG	24.68	< 0.001	0.460	0.0001
CA	3.82	< 0.001	0.220	0.0045
P	2.70	0.003	0.109	0.1633
TP	2.49	0.007	0.599	0.0001
ALB	3.96	< 0.001	0.269	0.0005
GLB	2.42	0.008	0.566	0.0001
A/B	1.86	0.048	-0.218	0.0048
BIL	2.87	0.002	0.232	0.0027
ALK	1.51	0.131	-0.172	0.0276
LDH	2.72	0.003	0.510	0.0001
GGT	0.97	0.479	0.075	0.3398
AST	1.93	0.040	0.336	0.0001
ALT	2.68	0.004	0.353	0.0001
BUN	5.09	< 0.001	-0.459	0.0001
CRE	11.50	< 0.001	0.422	0.0001
B/C	4.35	< 0.001	-0.534	0.0001
URIC	4.24	< 0.001	0.225	0.0037
FE	1.00	0.446	0.092	0.2391
TIBC	2.42	0.008	-0.296	0.0001
IS	1.99	0.033	0.269	0.0006
CHOL	4.16	< 0.001	0.060	0.4437
TRIG	13.88	< 0.001	0.677	0.0001

Figure 1. Total trawl distance (nautical miles) in each station for each monthly survey from March 1992 through February 1993.

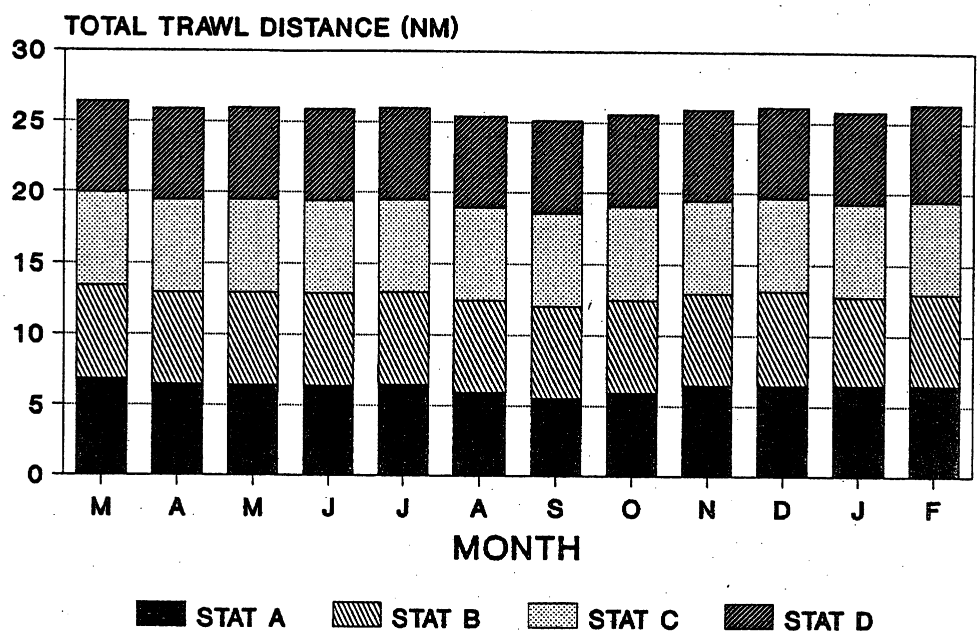


Figure 2. Total trawl time (minutes) in each station for each monthly survey from March 1992 through February 1993.

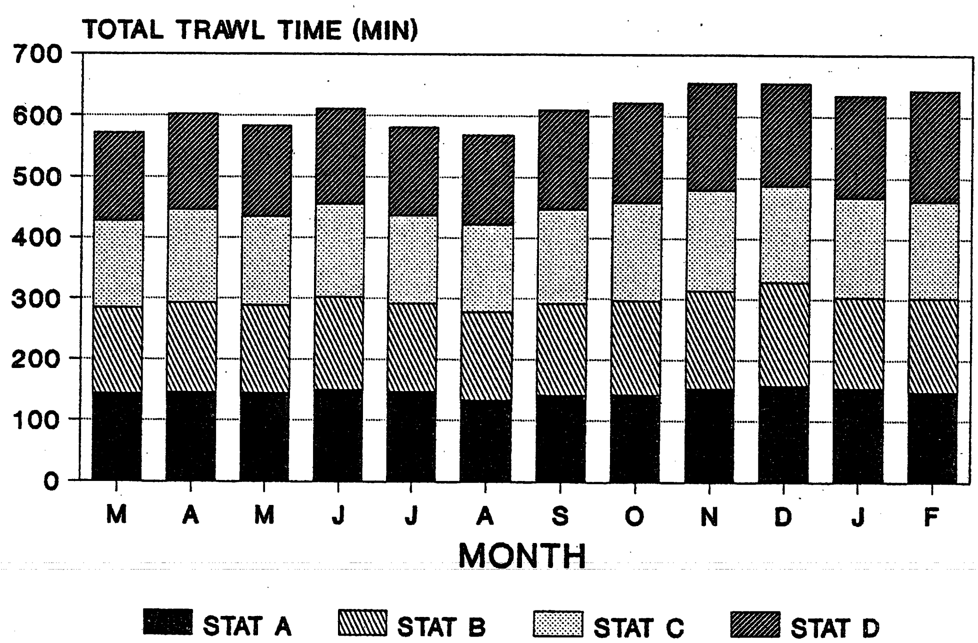


Figure 3. Numbers of sea turtles captured in port and starboard nets in each monthly survey from March 1992 through February 1993.

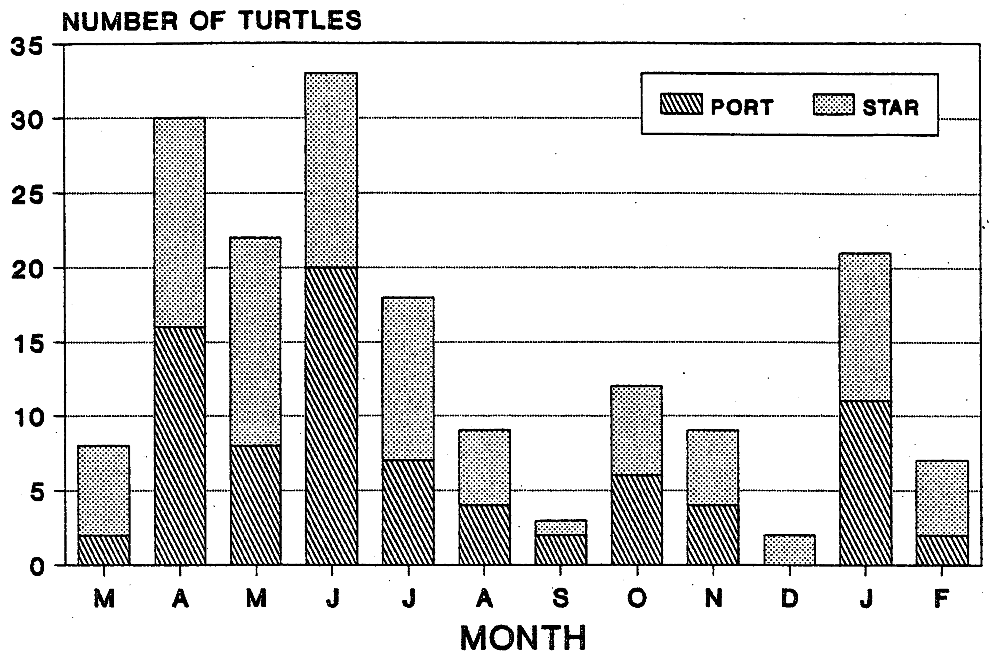


Figure 4. Numbers of loggerheads captured in each station in each monthly survey from March 1992 through February 1993.

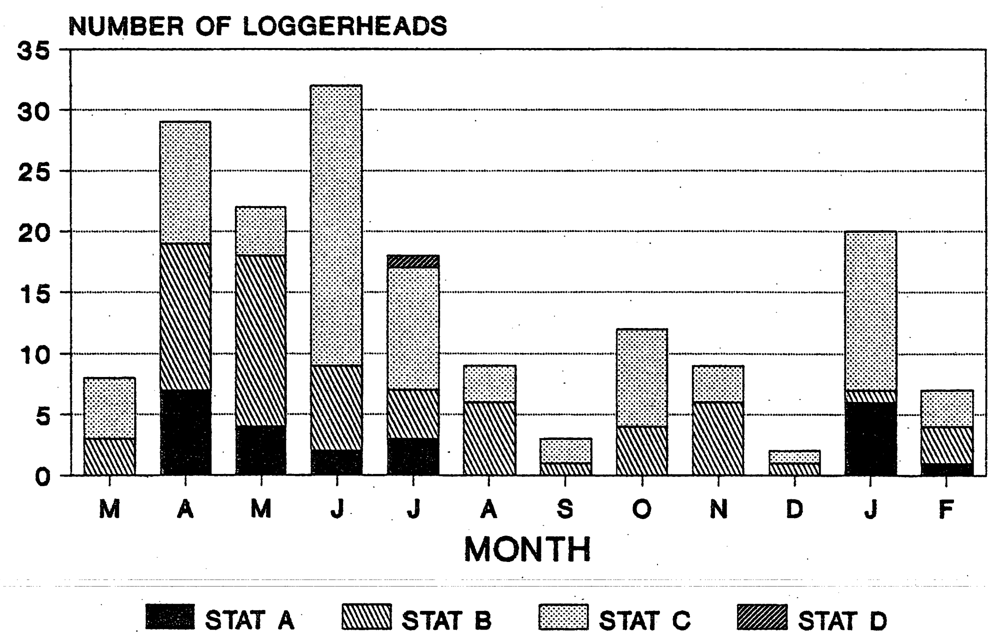


Figure 5. Total numbers of loggerheads captured in each station for the survey year (March 1992 through February 1993).

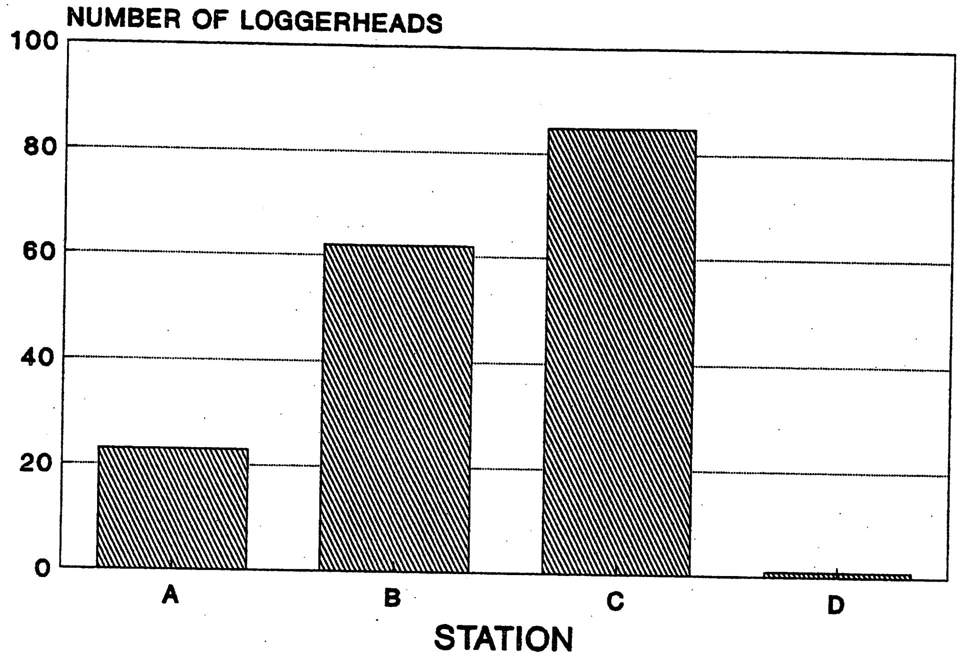


Figure 6. Size frequency of all loggerheads captured during the survey year (March 1992 through February 1993).

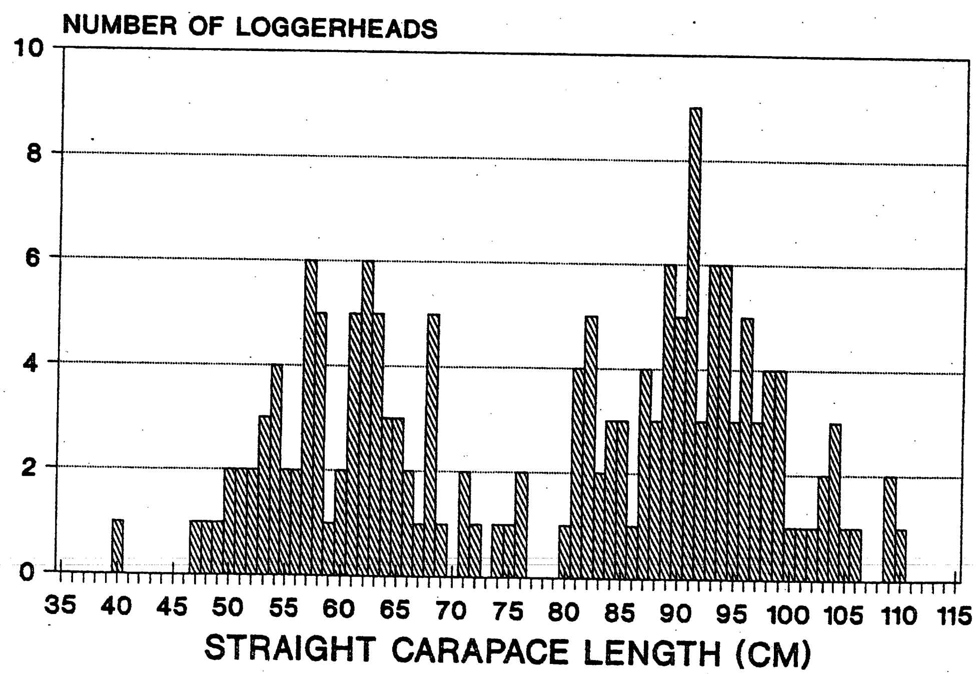


Figure 7. Size frequency of loggerheads captured during the March 1992 survey.

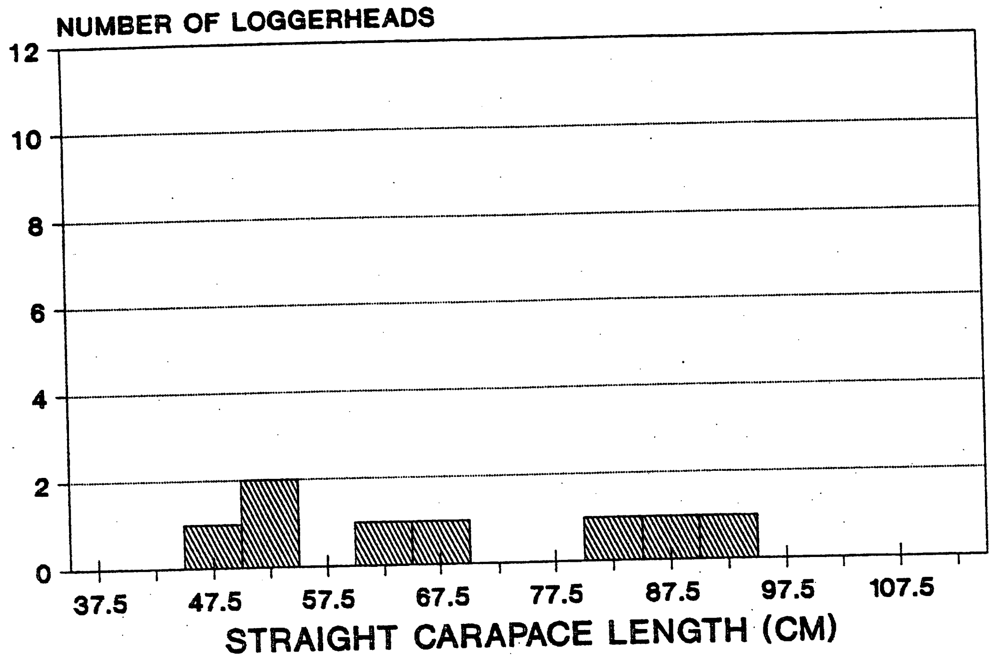


Figure 8. Size frequency of loggerheads captured during the April 1992 survey.

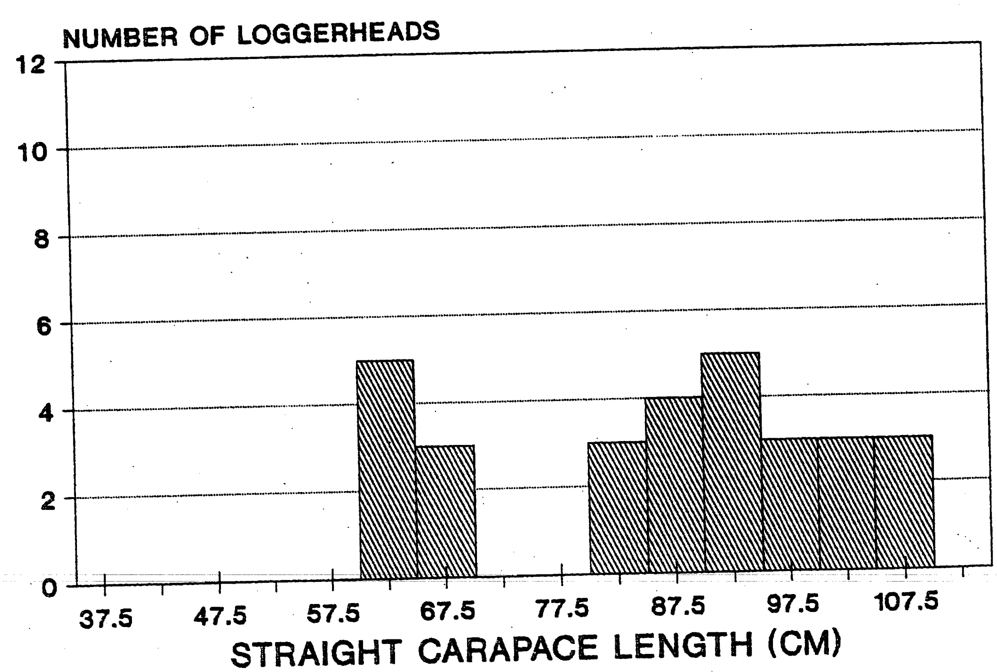


Figure 9. Size frequency of loggerheads captured during the May 1992 survey.

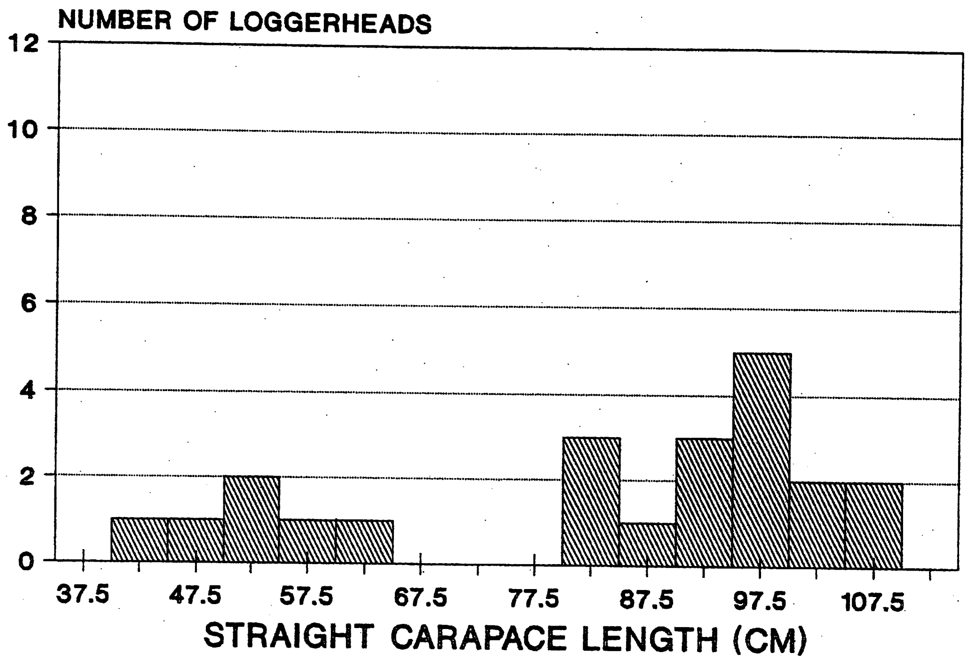


Figure 10. Size frequency of loggerheads captured during the June 1992 survey.

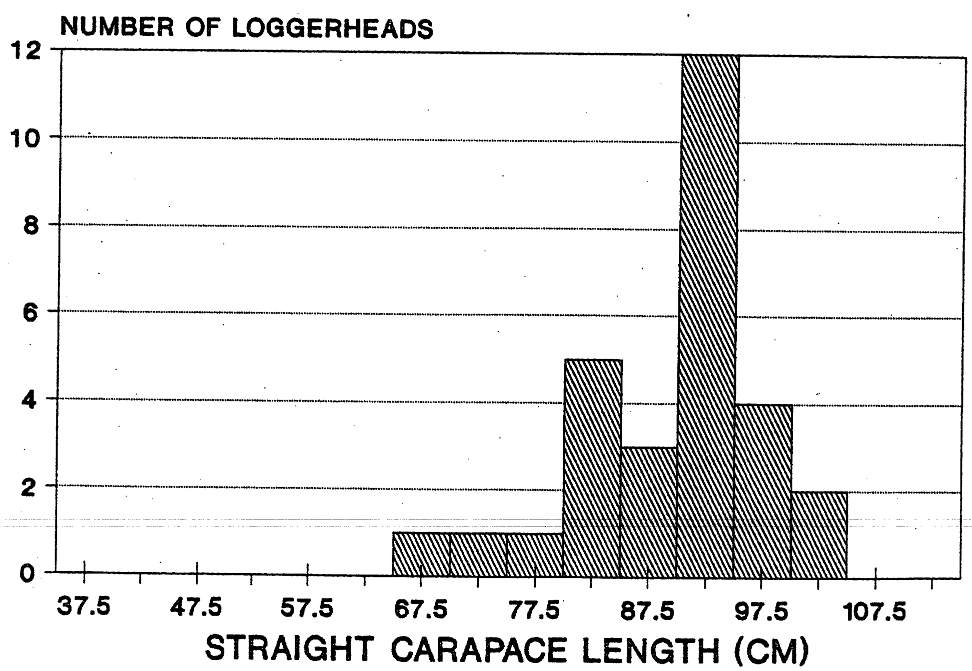


Figure 11. Size frequency of loggerheads captured during the July 1992 survey.

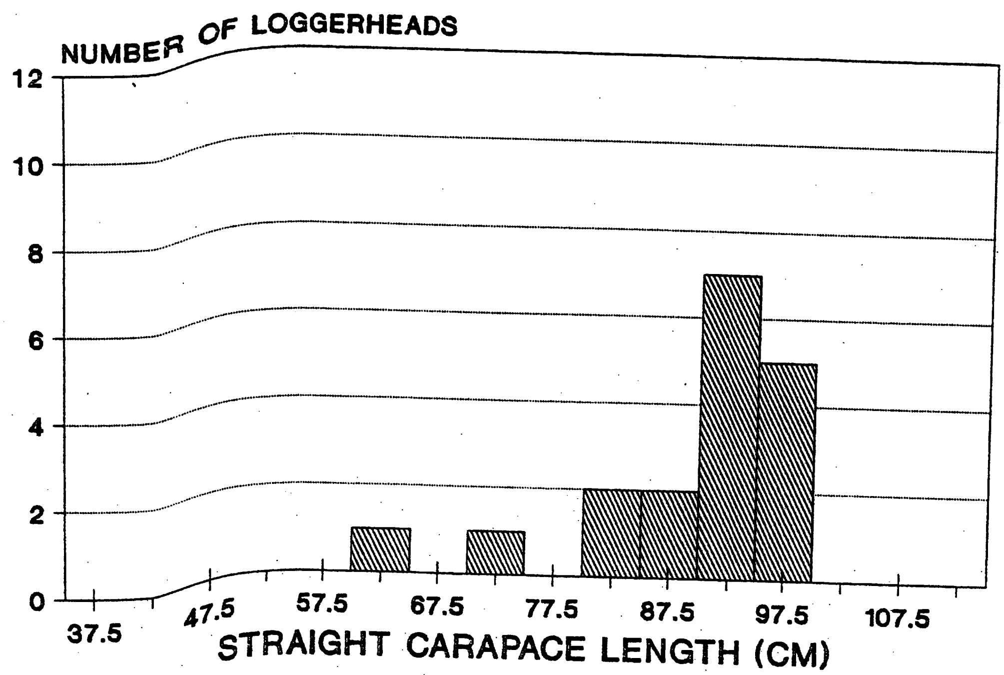


Figure 12. Size frequency of loggerheads captured during the August 1992 survey.

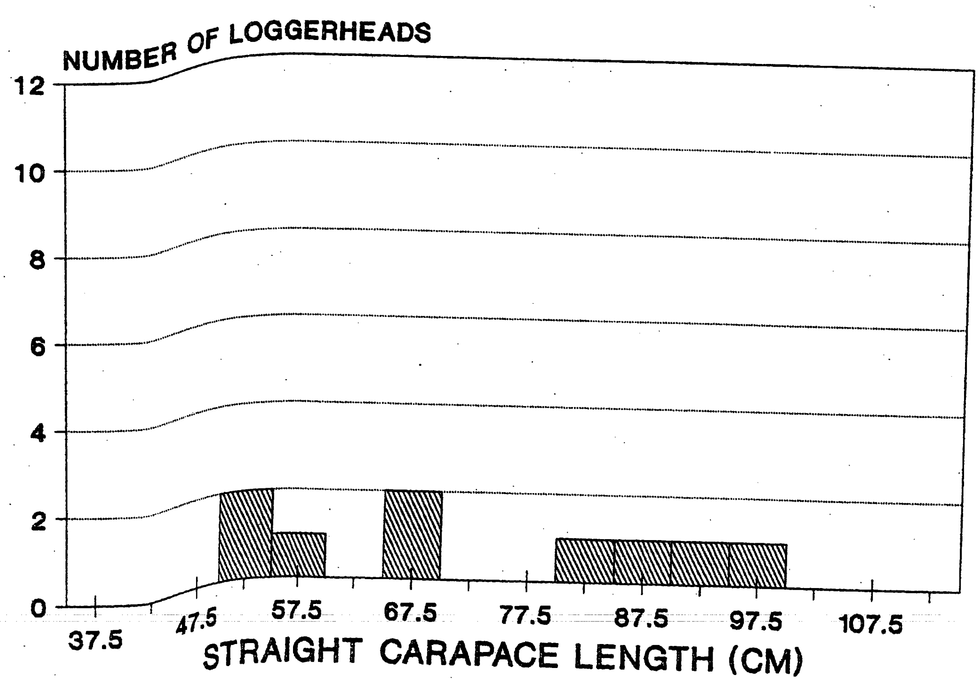


Figure 13. Size frequency of loggerheads captured during the September 1992 survey.

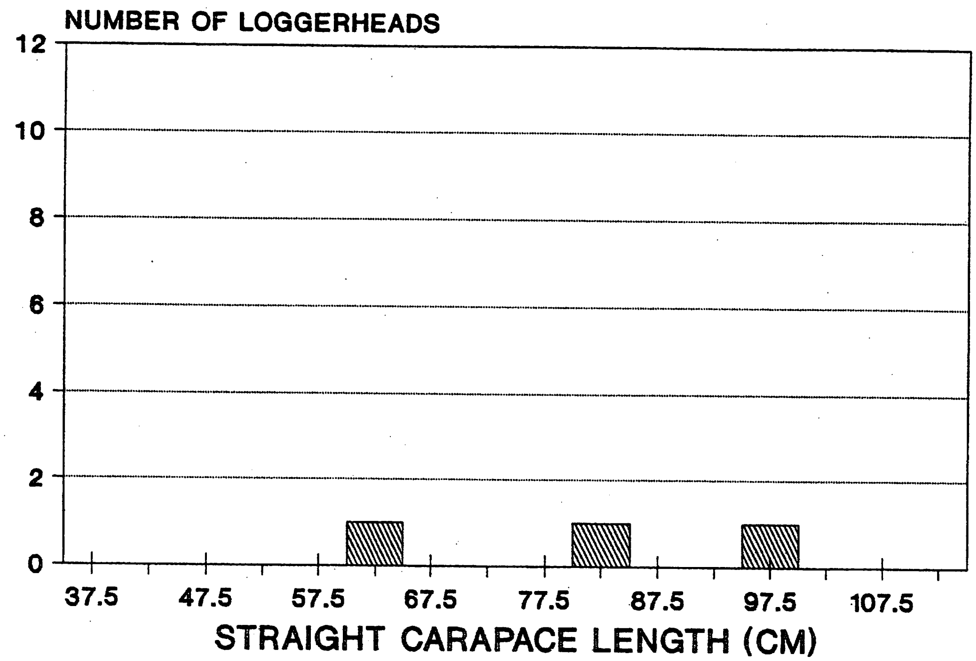


Figure 14. Size frequency of loggerheads captured during the October 1992 survey.

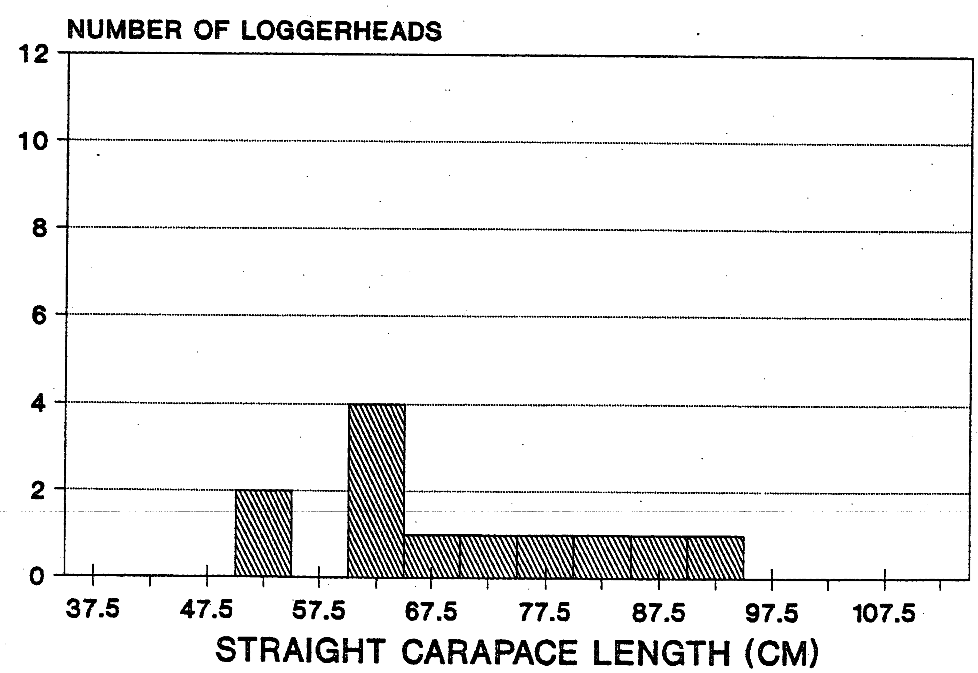


Figure 15. Size frequency of loggerheads captured during the November 1992 survey.

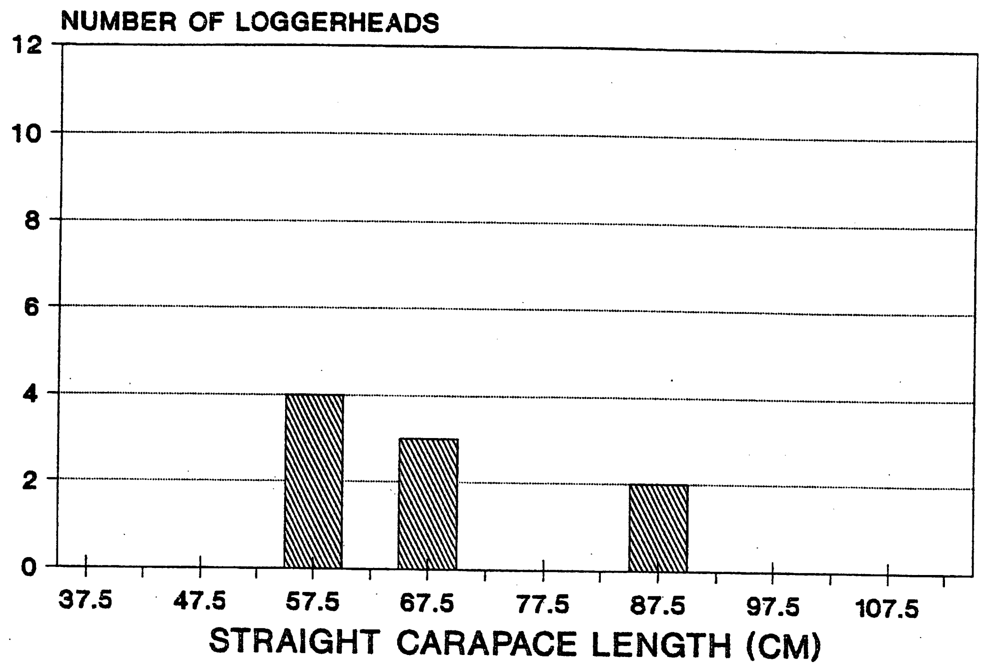


Figure 16. Size frequency of loggerheads captured during the December 1992 survey.

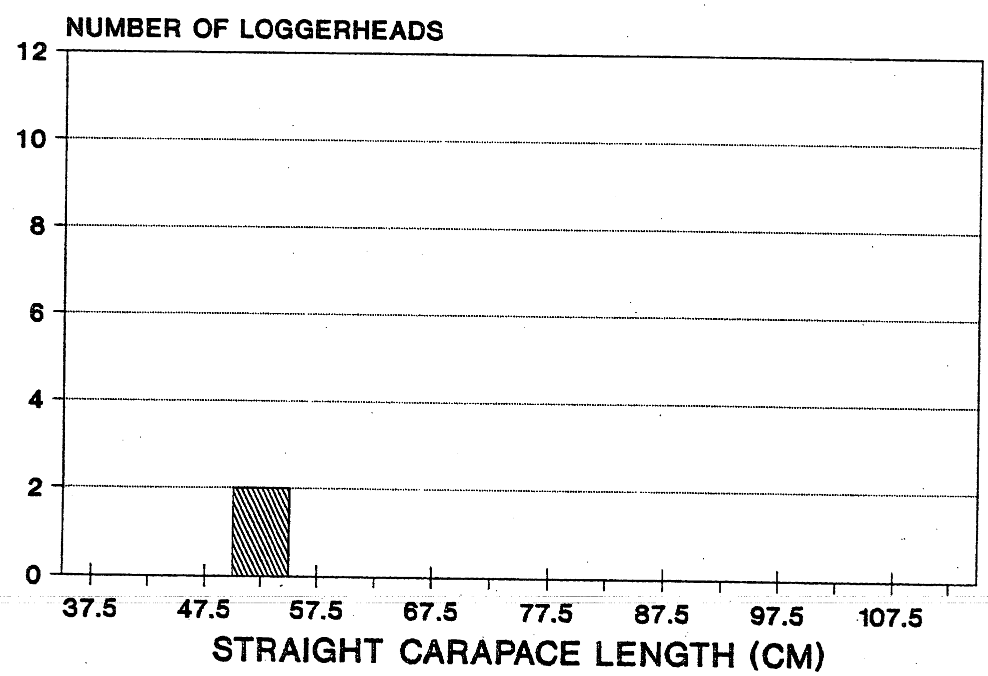


Figure 17. Size frequency of loggerheads captured during the January 1993 survey.

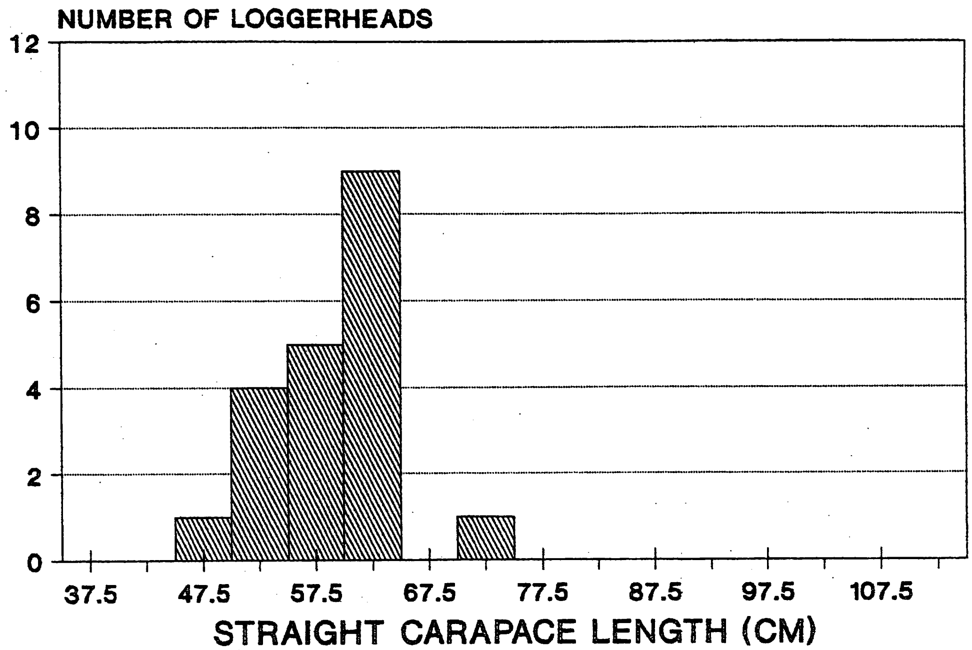


Figure 18. Size frequency of loggerheads captured during the February 1993 survey.

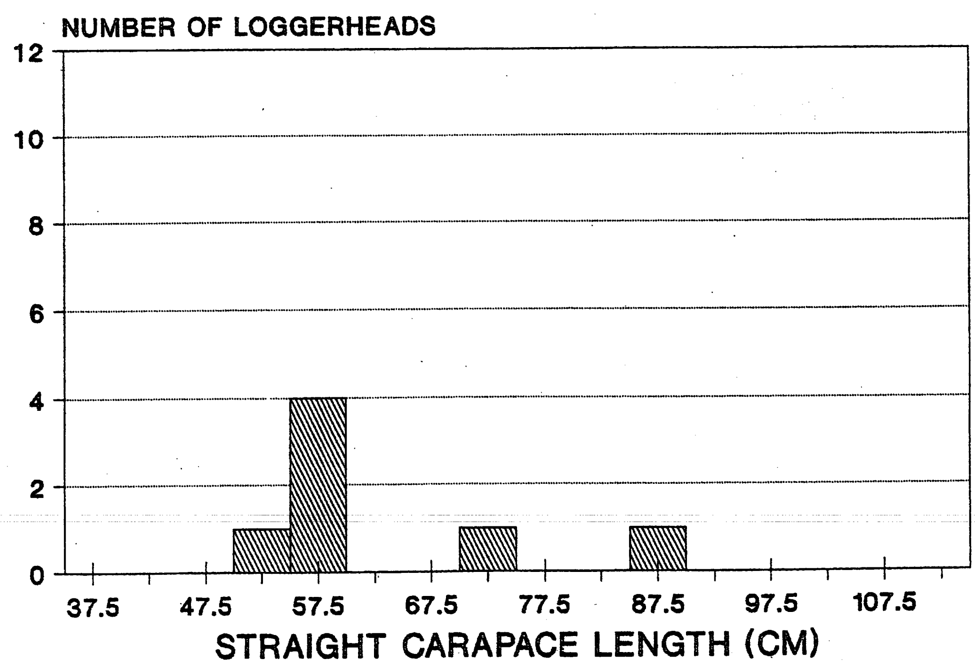


Figure 19. Distribution of juvenile and adult loggerheads captured during the monthly surveys from March 1992 through February 1993. Juveniles were defined as all turtles with SCL < 80.0 cm (see text for discussion).

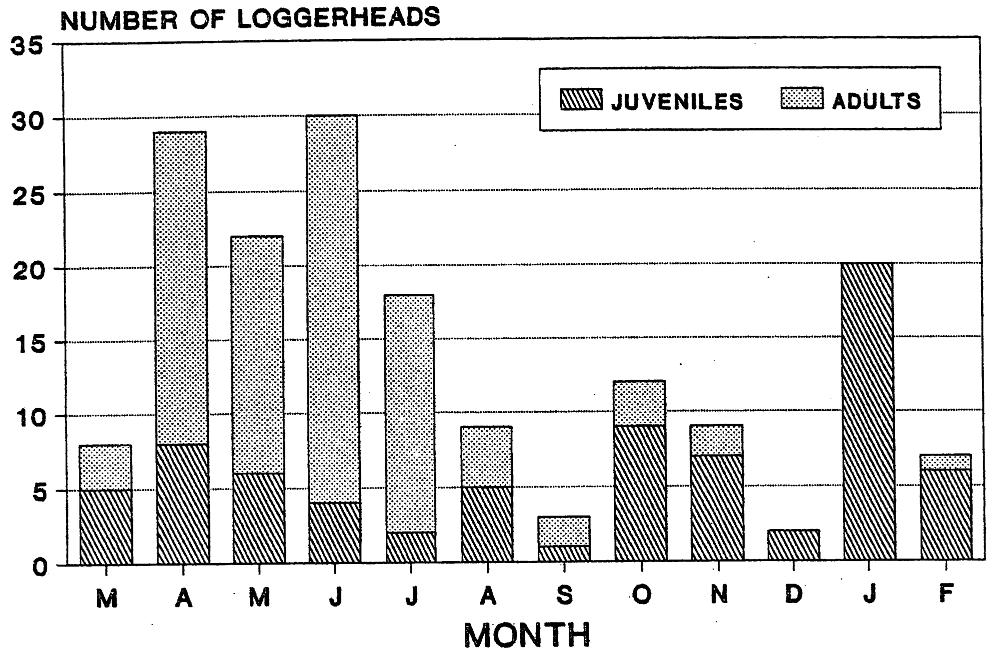


Figure 20. Water and air temperatures (°C) recorded during each monthly survey from March 1992 through February 1993.

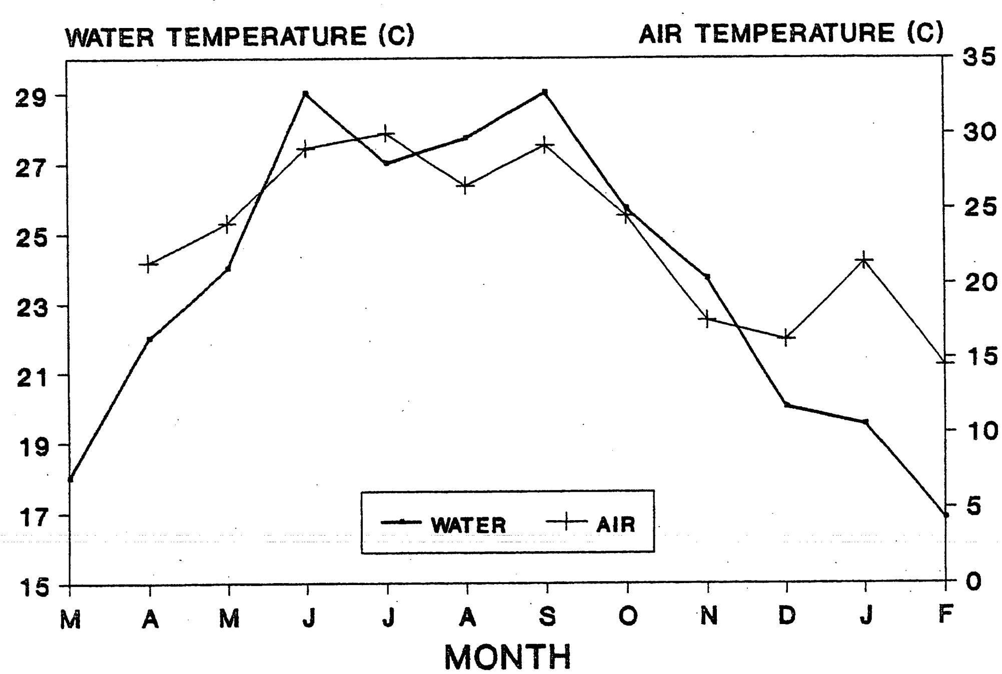


Figure 21. Water temperatures (°C) and numbers of loggerheads captured during each monthly survey from March 1992 through February 1993.

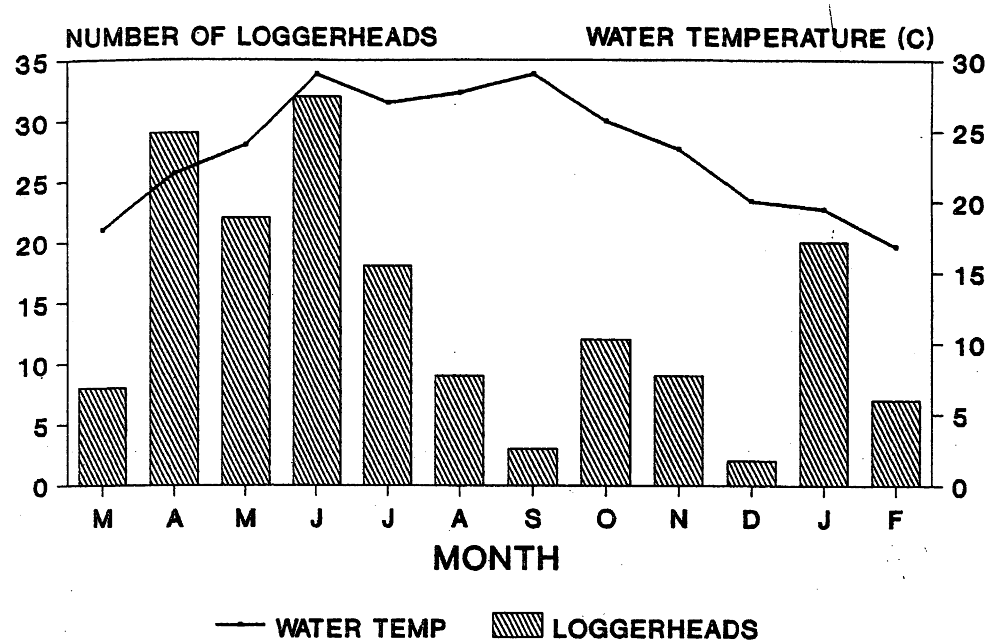


Figure 22. Water temperatures (°C) and numbers of juvenile loggerheads captured during each monthly survey from March 1992 through February 1993. Juveniles were defined as all turtles with SCL < 80.0 cm (see text for discussion).

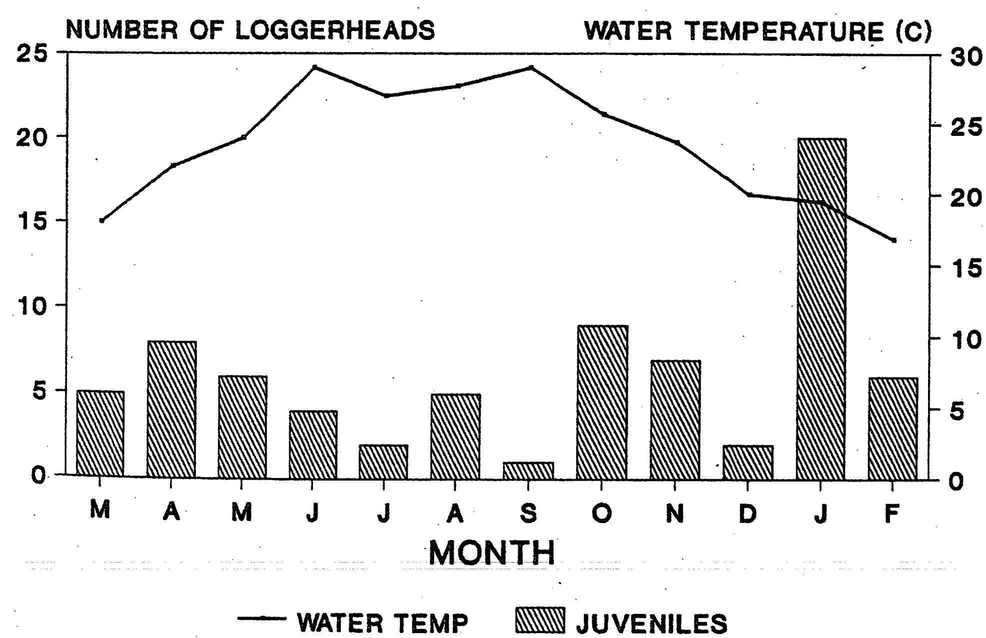


Figure 23. Water temperatures (°C) and numbers of adult loggerheads captured during each monthly survey from March 1992 through February 1993. Adults were defined as all turtles with SCL ≥ 80.0 cm (see text for discussion).

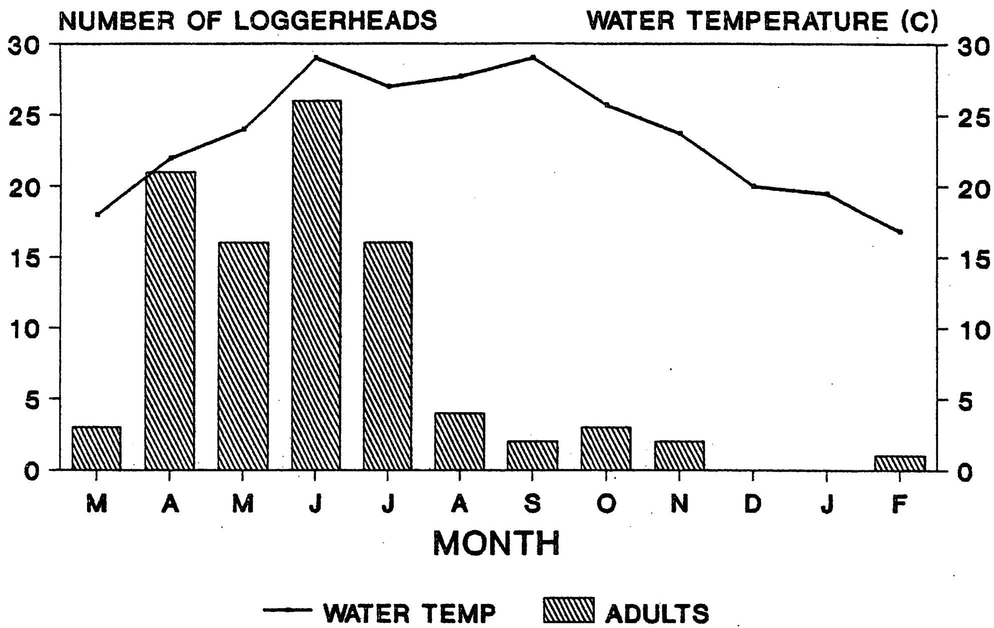
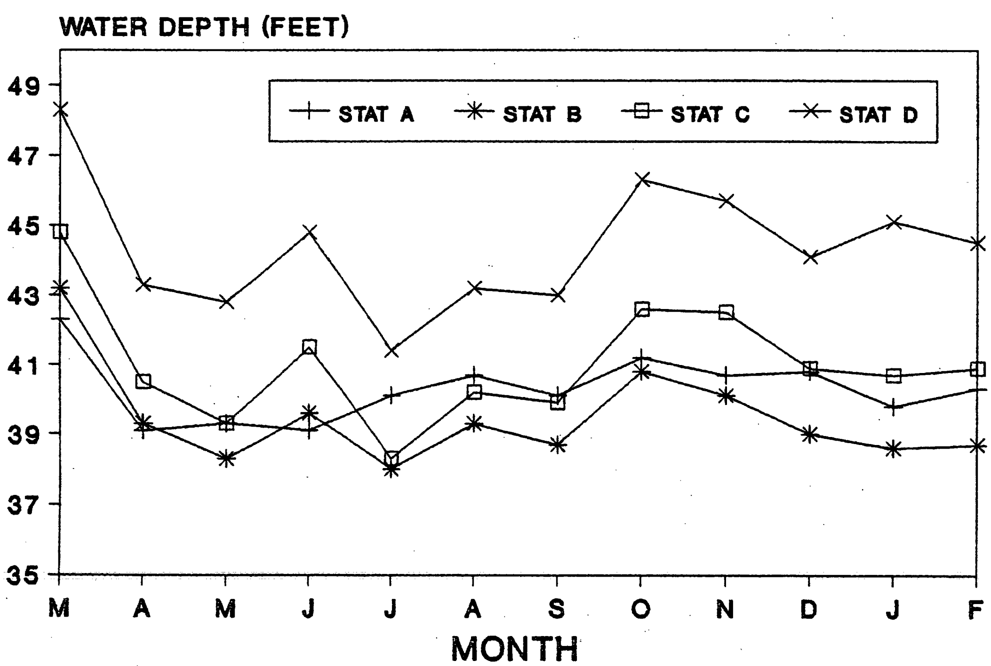


Figure 24. Mean water depth (feet) for each station during each monthly survey from March 1992 through February 1993.



APPENDIX 1

Trawler Net Specifications

Trawler Net Specifications

Manufacturer:	Billy Burbank, Jr., Fernandina, FL
Design:	2 seam, 3 bridal, mongoose style trawl net
Webbing:	4" bar, 8" stretch, 48 denier (gauge) twisted nylon and dipped; net length from wing tip to cod end is 66 feet; body designed with a 4 and 1 taper; wing-end height is 9 feet; center height 12' - 15' depending upon depth of trawl
Cod end:	13' long made of 4" stretch, 60 denier twisted nylon designed as 70 meshes around x 40 meshes rigged with standard choker rings 5/16 x 2.5" with a 7" stretch #260 polyethylene cod end cover or chaffing gear
Head rope:	60 feet, 7/16 poly-combination cable
Foot rope:	61 feet, 7/16 poly-combination cable
Leg line:	6 feet top and bottom
Floats:	long-line float attached to center cable (at tongue); two 8" deep water floats attached at each wing
Mud rollers:	white, clip-on 7" x 5" mud rollers were attached to foot rope and spaced 5 feet apart
Door size:	11' x 40; 9' x 40
Cable length:	(=bridal length) depended on Channel bottom conditions
Tickler chain:	no tickler chains were used

APPENDIX 2

Data Forms

MONTHLY TRAWLING AND TURTLE DATA SUMMARY SHEET
(Fax to Dave Nelson (601) 634-4016

Dates/Times__________________ Channel __________________________

		PORT NET			STARBOARD NET		
TOW	TIME	LOG	KEMP	GREEN	LOG	KEMP	GREEN
27							
28							
29							
30							
31							
32							
33							
34							
35							
36							
37							
38							
39							
40							
41							
42							
43							
44							
45							
46							
47							
48							
49							
50							
51							
52							

TRAWLING AND TURTLE DATA MONTHLY SUMMARY SHEET

[Fax to Dave Nelson (601) 634-4016]

Dates/Times:
Channel:

Type of Trawling:	
Survey	☐
Relocation	☐
PreDredge	☐

Vessel:
Captain:
Crew:

Dredge:	
Present	☐
Absent	☐

Average Weather:	
Water Temp:	°C
Air Temp:	°C
Wave Height:	ft.
Wind Speed/Dir:	
Bar. Pressure:	

Number of nets to repair:________________

Total Number of Tows:________________

Total Number of Turtles:
Loggerhead:
Kemp:
Green:

Number of recaptures this effort:________________

Number of recaptures previous effort (list tag #'s):

Bycatch/Comments:

TRAWLING INFORMATION

Channel:	Vessel:	Captain:
Crew:		

Date:
Tow #:
Shift #:
Dredge Location:
Total Tow Time:______________Min.

Survey:	☐
Relocation:	☐
PreDredge:	☐

Substrate:		
	Mud:	☐
	Sand:	☐
	Rocks:	☐
	Snag:	☐

Low Tide Time:	
High Tide Time:	
Ebb: ☐	
Flood: ☐	
Slack Ebb: ☐	Slack Flood: ☐

Water Temp. (B: ˚C) (M: ˚C) (S: ˚C)	
Wave Height:	ft.
Air Temperature:	˚C
Wind Speed/Direction:	
Barometric Pressure:	

Dir: In ☐ Out ☐	Loc: Green ☐ Center ☐ Red ☐

Begin Tow:	
Time:	
Depth:	ft.
Speed Mid-Tow:	knots
Latitude:	
Longitude:	
Loran:	
Station/Buoys:	

End Tow:	
Time:	
Depth:	ft.
Total Tow Distance:	ft.
Latitude:	
Longitude:	
Loran:	
Station/Buoys:	

Number of Turtles	
Port Net:	**Starboard Net:**
Logger:	Logger:
Kemp:	Kemp:
Green:	Green:

Bycatch/Comments:

____

____

____

Page #:

SEA TURTLE INFORMATION:

Channel: Port Canaveral

Date:

Tow #:

_____ of _____

Turtle Species: Net: Port ☐ Starboard ☐

Flipper Tag #	
Left:	
Right:	
Recapture: This effort:	☐
Previous effort:	☐

Sex:	
Male:	☐
Female:	☐
Unk:	☐

Weight:
kg
lbs

Head Width:
cm
in

Carapace S.L. Length:
cm
in

S.L. Width:
cm
in

Tail Length
(from plastron to tip:)
cm

Photos Taken:	
Yes	☐
No	☐

Blood Taken:	
Yes	☐
No	☐
Time:	

Telemetry Tag:	
Radio	☐
Sonic	☐
Satellite	☐

General condition of Turtle:

Turtle Released
Date:
Time:

Release Location
Lat:
Long:

LORAN: